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MIXING EMULSIFIED MINERAL LUBRICATING OILS WITH DEEP-WELL WATERS AND LIME-SULPHUR SOLUTIONS.

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SUITABILITY OF WATER AVAILABLE FOR SPRAY MIXTURES.

More than half of the citrus groves of Florida are located in artesian-well districts. A large proportion of the finer grades of fruit are grown in groves that are dependent wholly or in part upon water from deep wells for spraying purposes. The water from these wells is known as hard water, containing compounds of calcium, magnesium, sulphur, and other minerals (*2, 5, 6*) [1] in such proportions that the ordinary or unstabilized oil emulsions will not mix with it unless the water has been previously treated.

METHODS OF TREATING DEEP-WELL WATER.

For several years the citrus growers treated the water with caustic-potash fishoil soap before the emulsion was added to it (*9*). This method consisted simply of adding soap to the water until no free oil or greasy scum formed when the emulsion was poured in. The quantity of soap necessary to accomplish this varied for the different wells, and each grower had to determine this by trial. A small but measured quantity of soap was dissolved in a barrel of water and left standing a few minutes before the emulsion was added. If a greasy scum formed, the quantity of soap was insufficient. For the next trial a larger proportion of soap was used and the emulsion added as before. This was a rather expensive method, since the

[1] Serial numbers (italic) in parentheses refer to "Literature cited," at the end of this bulletin.

water from some deep wells required from 4 to 6 pounds of soap to 50 gallons, while most of them required between 1½ and 3 pounds each (*1*).

A less expensive method was desirable, and it was found that a combination of caustic soda and fishoil soap gave most excellent results. Considerable experimental work proved that 8 ounces of caustic soda and from 1 to 2 pounds of soap would be sufficient for any deep-well water in Florida thus far tested (*9*). The caustic soda was dissolved in a small quantity of water, which was then poured into the water to be used for spraying. The soap was likewise dissolved in a small quantity of water, which was then added to the water already treated with the caustic soda. After this mixture had stood about a minute the emulsion was added. This method has never been known to fail. It proved satisfactory even in slightly brackish water at Miami Beach.

VALUE OF COMBINATION SPRAYS.

In the citrus-growing sections of the southeastern United States and the West Indies it is often necessary to spray for rust mites with some form of sulphur and at about the same time to spray for white flies and scale insects with an emulsion made of lubricating oils. For many years soda-sulphur and potash-sulphur solutions have been combined with the oil emulsion for this purpose with reasonably satisfactory results. The oil emulsion is only partially effective against rust mites, while the soda-sulphur has little or no effect on white flies and scale insects at the rate of dilution usually employed. This mixture is compatible, and the resultant spray material contains no precipitate when soft waters are used. The soda-sulphur solution, according to the experiments, will not render deep-well water miscible with oil emulsion. It can, however, be substituted for the caustic soda in the formula wherein caustic soda and fishoil soap are used. When the mixture is satisfactory, it is unnecessary to use an agitator in applying it to citrus trees. The likelihood of injury following its use is no greater or little greater than when each material is applied separately at about the same strength or perhaps a slightly greater strength. Numerous examinations extending over more than 10 years have shown that this combination spray is just as effective against rust mites, white flies, and scale insects as when the materials are applied separately.

STABILIZED OIL EMULSIONS.

While this combination has been generally satisfactory, the results indicate that the soda-sulphur or potash-sulphur solutions when applied alone are not very satisfactory as a spray to control rust mites. At any rate, they have never been found to be so satisfactory as the lime-sulphur solution. It was therefore thought probable that a better combination spray would result if the oil emulsions were used with the lime-sulphur solution, and that the combination would retain the better properties of each spray.

Although any good unstabilized oil emulsion will mix with the soda-sulphur and potash-sulphur solutions, this is not the case with

the lime-sulphur solution. After much experimentation and several years of practical application in citrus groves it has been found that an oil emulsion which has been stabilized with any one of several different colloidal substances will mix with practically all deep-well waters in Florida. These stabilized oil emulsions will also mix with lime-sulphur solutions, making a combination spray for white flies, scale insects, and rust mites (*7*). Experiments were conducted from 1916 to 1919 to determine whether an oil emulsion could be mixed with a lime-sulphur solution to make a satisfactory combination spray (*8*). While these experiments were under way, Jones (*4*) obtained a patent covering the use of glue as a stabilizer for oil emulsions so that they will mix with lime-sulphur solutions. This combination has been very effective in controlling red spiders on deciduous fruit trees in California (*3*).

METHODS OF APPLYING COLLOIDAL SUBSTANCES.

Experiments conducted by the writers during the past six years show that certain colloidal substances, such as casein, milk, skimmed-milk powder, gelatin, corn meal, wheat flour, cornstarch, and laundry starch are equal to glue as stabilizers in rendering oil emulsions miscible not only with deep-well waters but also with lime-sulphur solutions at various dilutions ranging from 1–10 to 1–100.

These materials may be divided into two classes:

(1) Those which are most effective when not heated to 170° F., such as casein, gelatin, skimmed-milk powder, and glue.

(2) Those which are most effective when heated almost to the boiling point, such as cornstarch and laundry starch, wheat flour, and corn meal.

There are several methods of using these materials as stabilizers. Perhaps the most practical is to add them to the emulsion just before it is to be poured into the spray tank of diluted lime-sulphur solution or deep-well water. If this method is followed, all danger from fermentation or other deterioration is avoided.

To use the materials that do not require heat, simply dissolve them in either cold or hot water and then pour the solution into the emulsion.

To use the materials that require heat, it is necessary to make them into a paste by heating; afterwards they may be added to the emulsion. These stabilizers may be added to the emulsion just after it has been made and barreled. The same directions for their use should be followed as when they are to be used at once. When this method is used, if the emulsion is to be kept more than three or four days in summer or for a somewhat longer period in winter, a strong preservative should be added to prevent fermentation. For this purpose add from three-fourths to 1 per cent of pure carbolic acid,[2] or about the same of liquor cresolis compositus. The stabilized emulsions deteriorate rapidly, and they should be used soon after mixing. The operator should proceed on a small scale at first and gradually enlarge the operations as success justifies.

[2] Commercial crude carbolic acid containing 50 per cent of phenols may be used at the rate of 1½ to 2 quarts in 50 gallons.

It is also practicable to add glue or any material which requires heat to the oil, water, and soap, when these are to be heated to make the emulsion. Such a formula is as follows:

PREPARATION OF BOILED OIL EMULSION.

Paraffin oil or lubricating oil	2 gallons.
Water	1 gallon.
Caustic-potash fishoil soap	2 pounds.
Glue (or other stabilizer)	1 pound.

Put the oil, water, soap, and stabilizer into a kettle or other vessel that will stand fire and heat to the boiling point. While still very hot, but after removal from the fire, pump the material into another vessel with a bucket pump and then pump back again. The quantities stated in the foregoing formula are for use with about 200 gallons of water or with the same volume of diluted lime-sulphur solution. If an emulsion thus made is used in a few days, no preservative is needed; otherwise a preservative will be necessary to prevent fermentation.

In order to render oil emulsions miscible so that they will mix with either deep-well waters or diluted lime-sulphur solutions, the following quantities of the various stabilizers are required for each 3 gallons of emulsion:

PROPORTIONS OF STABILIZING SUBSTANCES.

Glue	1 pound	Wheat flour	1 pound
Skimmed-milk powder	1 pound	Cornstarch	1 pound
Casein	8 ounces	Laundry starch	1 pound

It is not necessary to limit the use of these stabilizers to a single material. A portion of one stabilizer can be used with a portion of another, but the required quantity of the combined materials should always be used. Thus, 8 ounces of glue may be used with 8 ounces of wheat flour or 4 ounces of casein. The use of stabilizers in smaller quantities has nearly always failed to produce satisfactory results.

There are several oil emulsions on the market in Florida which will mix with deep-well water and also with lime-sulphur solutions. Therefore, the citrus grower may either make the emulsion required or purchase it ready for use.

To use these stabilized oil emulsions with lime-sulphur solutions, the following procedure should be observed: Fill the spray tank nearly full of water and add the required quantity of lime-sulphur solution, after which the stabilized oil emulsion should be added. If a sufficient quantity of stabilizer has been used, the resulting precipitate of calcium soap should be very fine, and no greasy scum will come to the surface. If an insufficient quantity of stabilizer has been used, the precipitate will be coarse and granular, and in some cases a heavy oil mass will float on the surface. It is necessary to agitate this combination slowly while it is being applied.

To use a stabilized oil emulsion with deep-well water, all that is necessary is simply to add it to the water in the spray tank. Very little if any precipitate will form if the emulsion has been properly stabilized, and no agitator is necessary in applying it to the trees. If a greasy mass forms, the mixture is not perfect and should not be used.

EXPERIMENTAL RESULTS AND THEIR COMMERCIAL APPLICATION.

Results obtained from experimental work show that about the same quantity of stabilizer is required to render an emulsion so that it will mix either with deep-well water or with various dilutions of lime-sulphur solution ranging from 1–10 to 1–100.

When the combination of oil emulsion and lime-sulphur solution is properly made, it is a reasonably safe spray for either citrus foliage, branches, or fruit. If it is not made correctly and is applied to the trees, considerable injury may follow. This spray in the hands of a competent grove manager will give satisfactory results, but it is certainly not a combination that is adapted to the use of irresponsible or incompetent grove managers.

This combination spray is highly effective when used against scale insects, white flies, and rust mites. Several citrus growers are using it exclusively in spraying for the control of insect pests and mites attacking citrus trees. The fungicidal effect of this combination spray is no more marked than when an equivalent dilution of lime-sulphur solution is used alone.

The stabilized oil emulsions have met with much favor among many of the largest citrus growers in Florida, who no longer find any difficulty in using the untreated water from deep wells.

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